Information-theoretic inflectional classification

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  - Reproducible classifications
  - Commensurable in several languages
  - Basis for theoretical and typological comparisons.

Groups of lexemes that inflect alike.

	INF	PRES.3.SG	PRES.3.PL	PP
TENIR 'hold'	təniʁ	tjɛ̃	tjɛn	təny
FINIR 'finish'	finiʁ	fini	finis	fini
HAÏR 'hate'	aiʁ	ɛ	ais	ai
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1. What form should an IC system take ?
2. What generalisations should we infer from the data ?
3. How do we measure which lexemes inflect alike ?
4. How do we find the best classes among all possible ones ?

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Inflection classes: Cohesive or distinctive ?

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  - **Perfectly distinctive** : *fewer large classes with exceptions*

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Inflection classes: Cohesive or distinctive ?

- Dressler and Thornton's terminology (1996):
- Micro-classes
  - *Internally homogeneous : numerous small, similar classes*
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- **Micro-classes**
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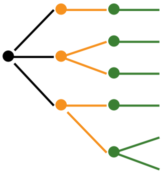
- Combined in a hierarchy. (Corbett and Fraser, 1993; Dressler and Thornton, 1996; Brown and Evans, 2012)



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- **Binary alternation patterns**

$$/\textit{bæg}/\ (\textsc{sg}) \rightleftharpoons /\textit{bægz}/\ (\textsc{pl})$$
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- **Binary alternation patterns** $\quad \begin{matrix} /bæg/\ (\textsc{sg}) \rightleftharpoons /bægz/\ (\textsc{pl}) \\ /X/\ (\textsc{sg}) \rightleftharpoons /Xz/\ (\textsc{pl}) \end{matrix}$
  - *Captures the* ***implicative relation*** *between each pair of cells.*
- Crucial difference:
  - global segmentation over the whole paradigm.
  - local segmentation over pairs of forms.

- **Global** : On the basis of a whole paradigm.
- **Local** : On each pair of cells.

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Lexeme	INF ⇌ PRS.3SG	INF ⇌ PRS.3PL	INF ⇌ PST.PTCP	…
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FINIR 'finish'	Xʁ ⇌ X	Yʁ ⇌ Ys	Zʁ ⇌ Z	
HAÏR 'hate'	aiʁ ⇌ ɛ	Yʁ ⇌ Ys	Zʁ ⇌ Z	…
PELER 'peel'	X_1əX_2e ⇌ X_1ɛX_2	Y_1əY_2e ⇌ Y_1ɛY_2	Z ⇌ Z	
LAVER 'wash'	Xe ⇌ X	Ye ⇌ Y	Z ⇌ Z	
TASSER 'press'	Xe ⇌ X	Ye ⇌ Y	Z ⇌ Z	

- This leads us to a **clustering problem** :
  - Evaluate fitness of clusters
  - Explore the search space

- **Minimum description length** (Rissanen, 1984) : Choose the model allowing for the shortest description of the data.
- A partition of the set of lexemes is better than another one if it leads to a more economical description of the system. (Sagot and Walther, 2011; Walther, 2013)

$$DL(description) =$$

$$length(description) \times - \sum_{x \in symbols(description)} P(x) log_2(P(x))$$

- **Microclasses**: number of bits necessary to encode the mapping between each lexeme and its microclass.

$$M = - \sum_{m \in Microclasses} |m| \times \log_2\left(\frac{|m|}{|lexemes|}\right)$$

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- **Grammar**: number of bits necessary to define the list of patterns available for each cluster and each pair of cells.

$$G = -\sum_{c \in clusters} \sum_{A,B \in pairs(cells)} |patterns_c^{A,B}| \times log_2(\frac{|patterns_c^{A,B}|}{|patterns^{A,B}|})$$

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- **Lexicon**: number of bits necessary to encode the mapping between each microclasse and its clusters.
- **Grammar**: number of bits necessary to define the list of patterns available for each cluster and each pair of cells.
- **Residual ambiguity**: number of bits necessary to encode the mapping of each microclass to its pattern given the lexicon and the grammar

$$R = -\sum_{c \in clusters} \sum_{A,B \in pairs(cells)} \sum_{t \in patterns_c^{A,B}} |t| \times \log_2(\frac{|t|}{|c|})$$

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$$DL = M + L + G + R$$

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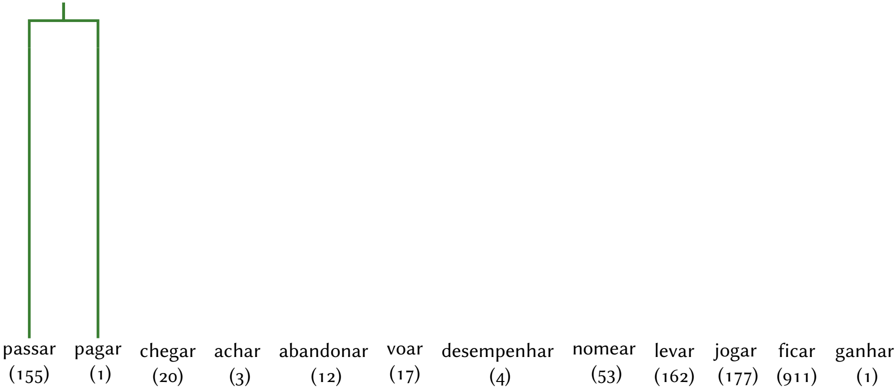
(a) Merge lexemes with identical patterns (micro-classes).

passar	pagar	chegar	achar	abandonar	voar	desempenhar	nomear	levar	jogar	ficar	ganhar
(155)	(1)	(20)	(3)	(12)	(17)	(4)	(53)	(162)	(177)	(911)	(1)

Clustering algorithm

(a) Merge lexemes with identical patterns (micro-classes).
(b) Merge the pair optimising descriptive economy (lowest DL).



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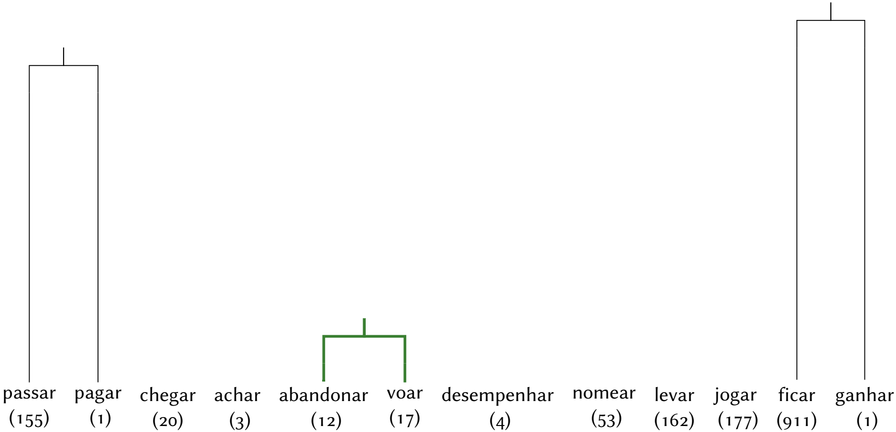

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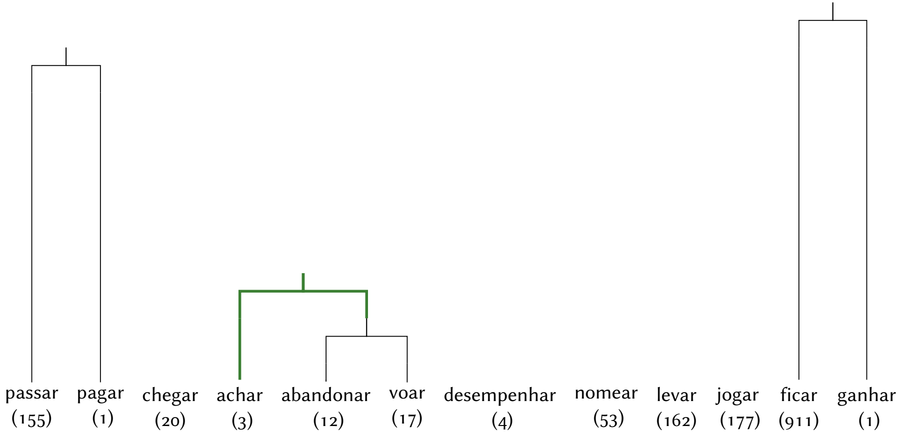

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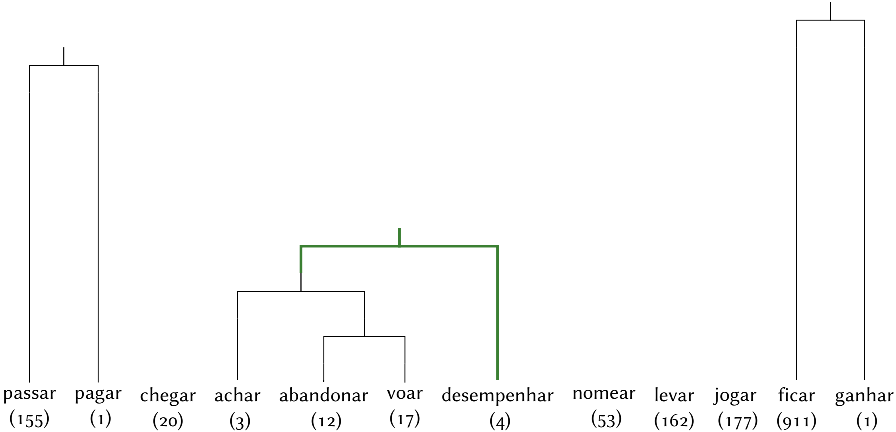

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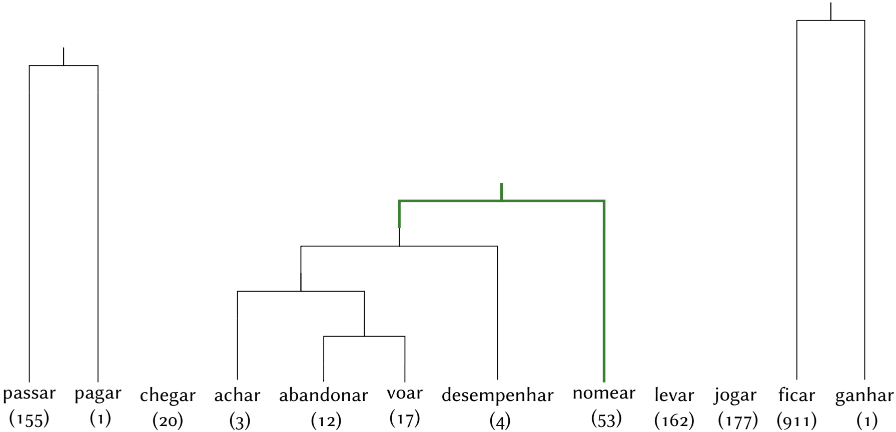

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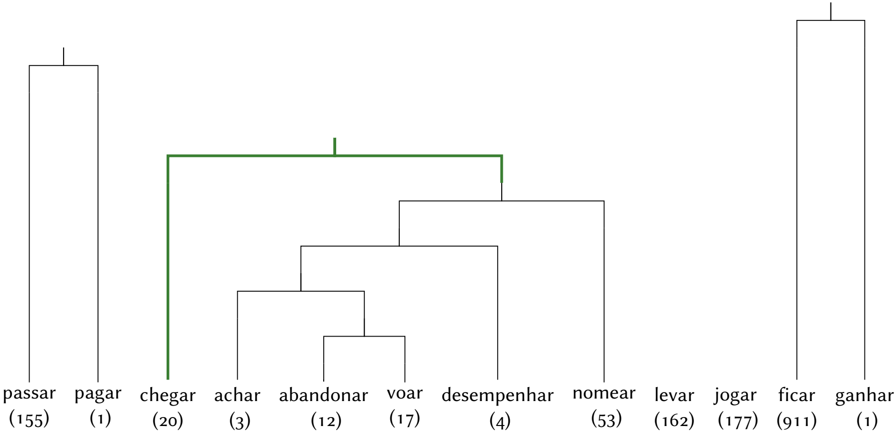

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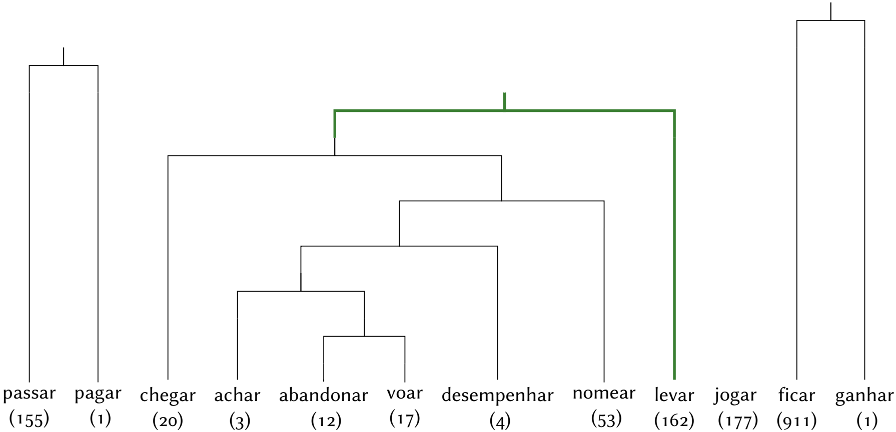

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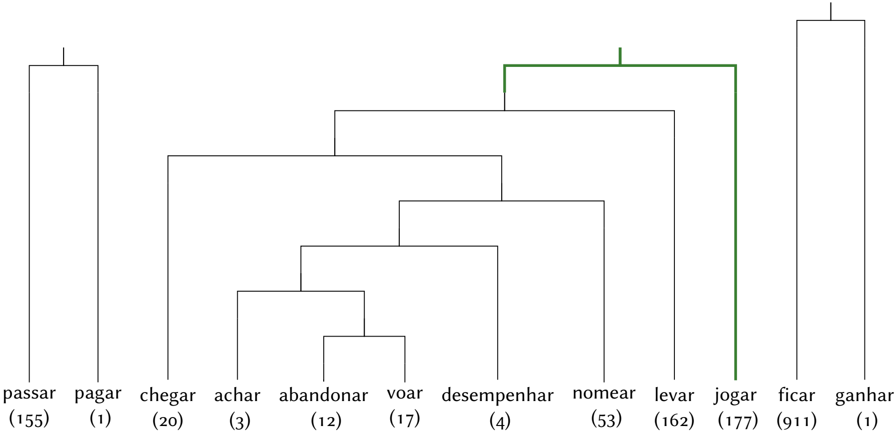

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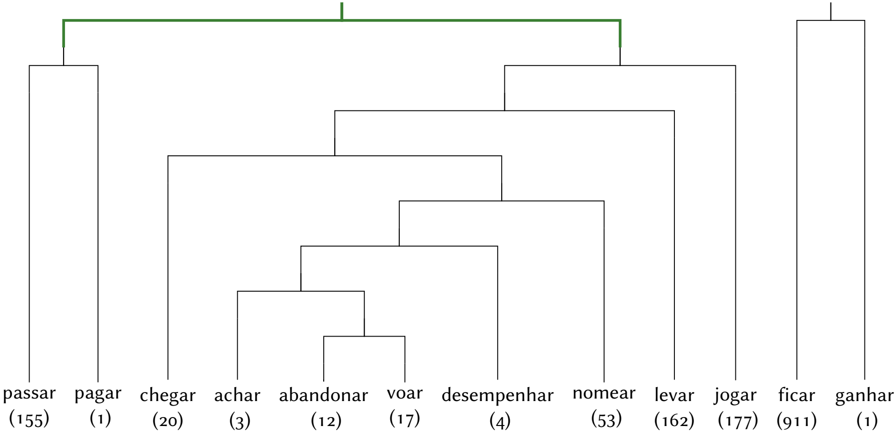

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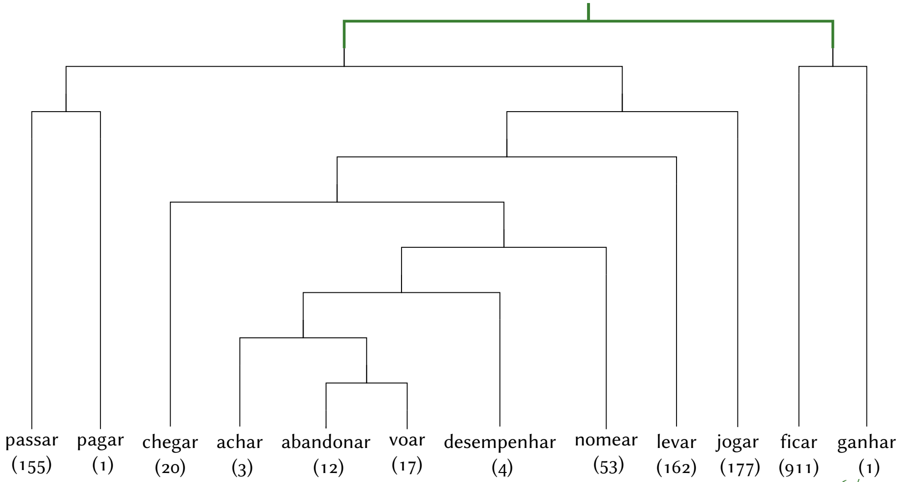

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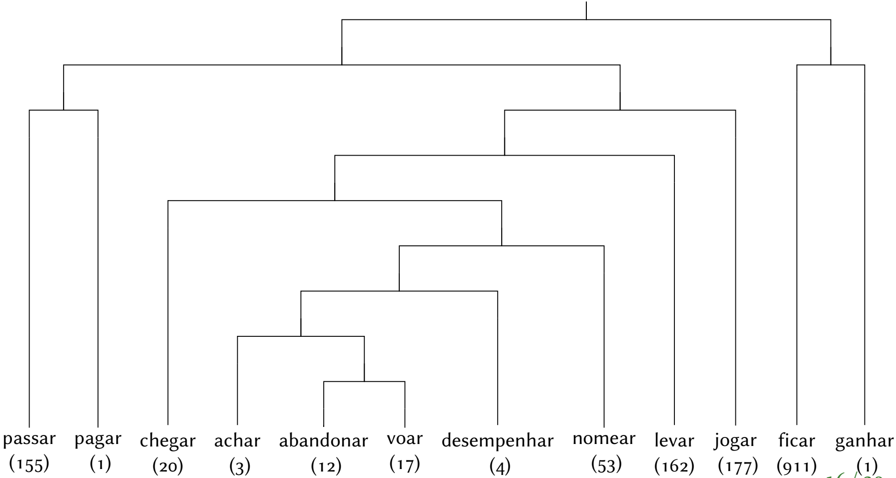

- As we merge clusters, we expect the DL to decrease.
- We define **macroclasses** when at some point, merging doesn't lead to a decrease.
  - Macroclasses optimise the size of the system, without any information loss.
  - It is an empirical issue wether a system has macroclasses or not.
- They do show up in our experiments.

Comparison to other works

	Generalisations	Criterion	Algorithm
Brown and Evans (2012)	raw paradigms	Compression distance	CompLearn
Bonami (2014)	Affixes	Edit distance	UPGMA
Bonami (2014)	Patterns	Hamming distance	UPGMA
Lee and Goldsmith (2013)	Sets of characters	DL variant	greedy bottom-up
Here	Local patterns	DL	greedy bottom-up
Here	Global patterns	DL	greedy bottom-up

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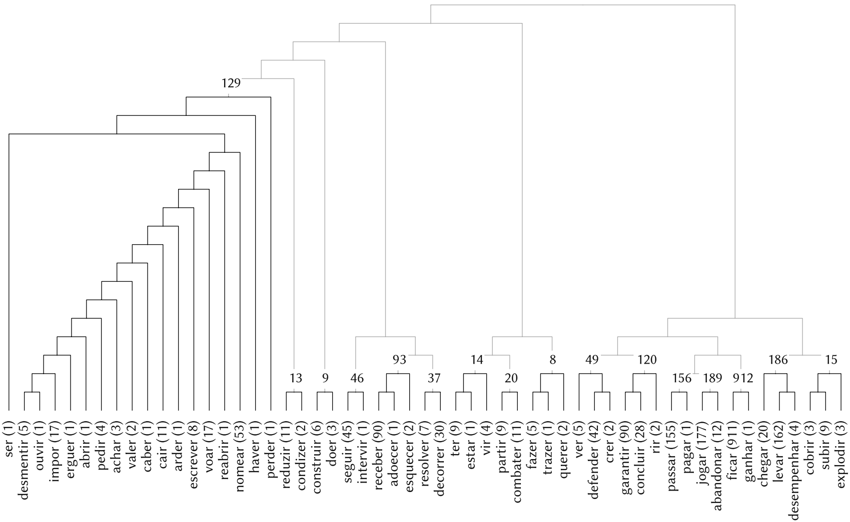
- Paradigm tables in phonemic transcription.
- **European Portugese**: Coimbra pronunciation dictionnary (Veiga et al., 2013) (1995 verbal entries).
- **French**: Flexique (Bonami et al., 2014) (5406 verbal entries).

Portugese inflection classes, with global templates



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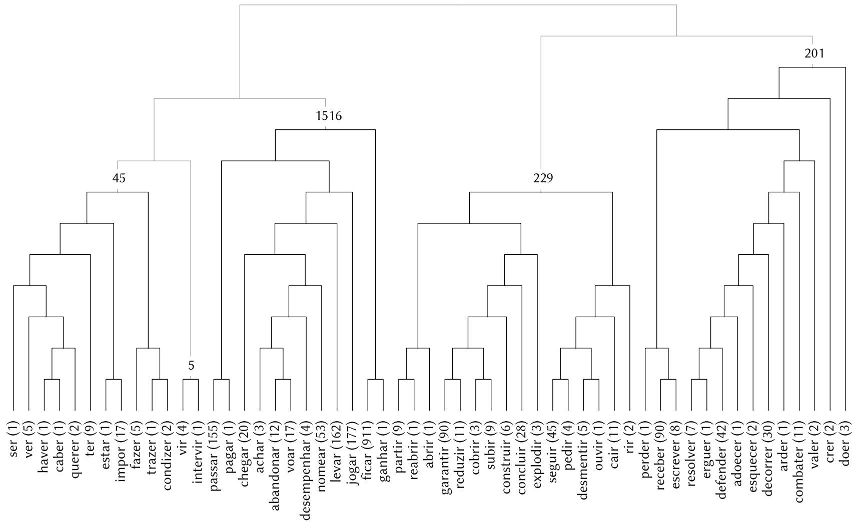

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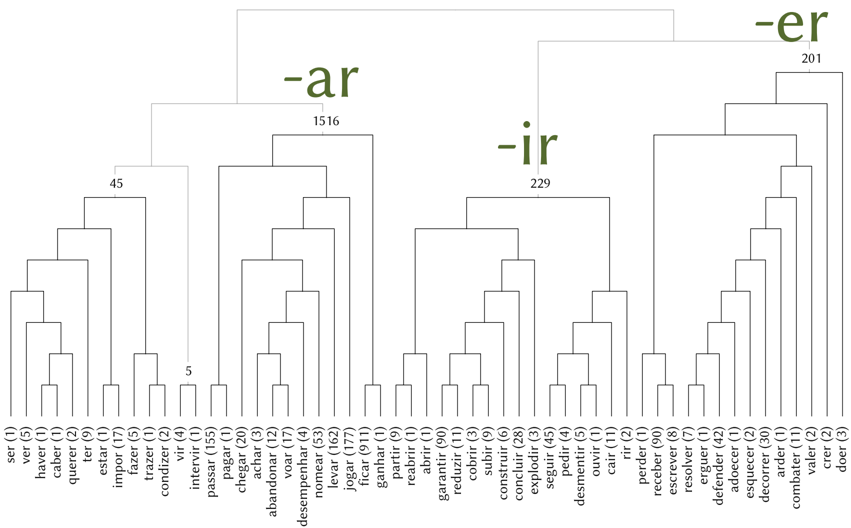
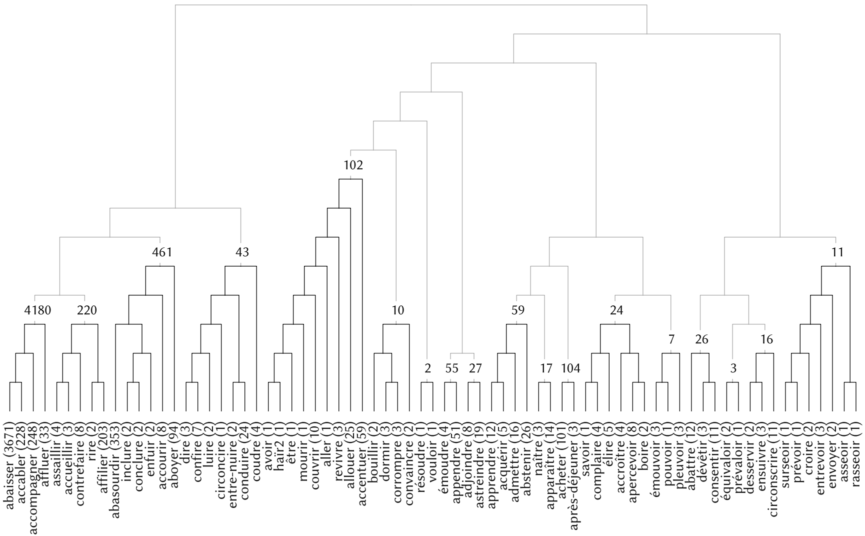


French inflection classes, with global templates



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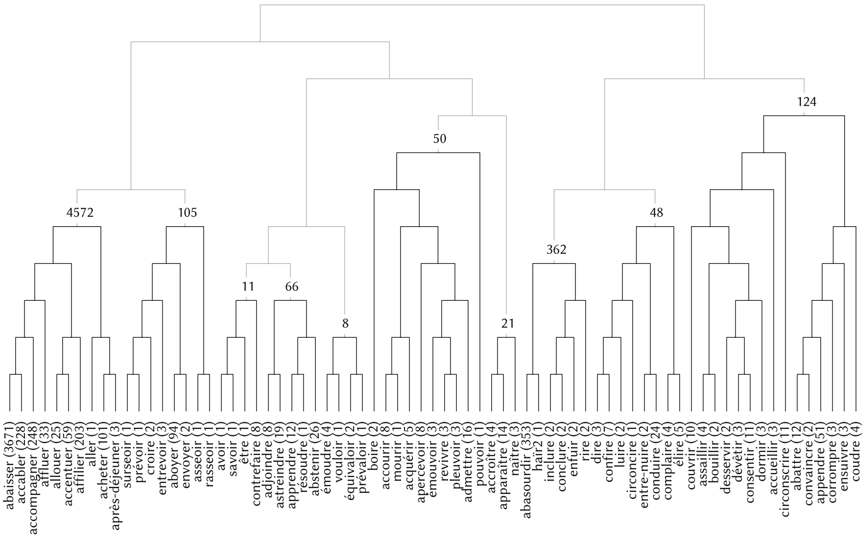

- **Main properties** :
  - Based on information-theoretic measures.
  - Relies on automatically inferred generalisations.
- **Compared to previous attempts** to automatise IC :
  - Segmentations not taken as granted.
  - Using a measure that evaluates the quality of the system allows us to infer relevant macroscopic generalisations.
  - No parameters to adjust: **Occam's razor** is the only criterion.
- **Local segmentation** better captures the structure in inflection system than global segmentations.
  - Supports the relevance of local patterns of alternation in abstractive approaches (Blevins, 2006).
  - Complementary to work on information-theoretic modeling of implicative structure (Ackerman et al., 2009; Ackerman and Malouf, 2013; Bonami and Beniamine, 2015)
- **Freely available code** : `http://qumin.gforge.inria.fr`

Qumin

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